INDUSTRY DEVELOPMENTS AND MODELS

Intelligent Systems: The Next Big Opportunity

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IDC OPINION

The next big opportunity for technology suppliers, system vendors, and service providers is being defined today by the migration from traditional embedded systems to Intelligent Systems. Embedded systems' adoption of high performance and highly programmable microprocessors, internet connectivity, and high-level operating systems—just as a start—means that they are getting smarter, they are evolving from fixed function and disconnected systems to more flexible and interconnected systems. IDC forecasts that:

- Intelligent Systems--those enabled with high-performance microprocessors, connectivity, and high level operating systems--will grow from 19% of all major electronic system unit shipments in 2010 to more than one third all systems by 2015.
- The market for Intelligent Systems will double from more than 1.8 billion units and over $1 trillion in revenue this year to nearly 4 billion units and over $2 trillion in revenue in 2015.
- The embedded semiconductor market equaled $33 billion in 2010 and will grow at a CAGR of 20% throughout our forecast period.

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Semiconductors: Personal Computing: Industry Developments and Models

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This Industry Developments and Models study centers on identifying the transformation of the embedded systems industry, including providing context around the market's size and forecast, and indentifying key attributes that companies must address in order to capture the growth of the market.

This study also introduces the new category name of Intelligent Systems to help describe the future of embedded systems. For over a decade IDC's semiconductor team has been advising and researching the embedded marketplace and this study serves as a good example of the growing collaboration between IDC and leading companies who share the vision of defining the market's direction.

This research and analysis is based on IDC's Embedded Microprocessor Market Model, which tracks opportunities for systems based on embedded microprocessors (eMPUs) in 168 end-markets. This model does not include microcontroller (MCU) or digital signal processor (DSP) based products.

SITUATION OVERVIEW

Industry Dynamics

The next big opportunity for technology suppliers, system vendors, and service providers is being defined today by the migration to more intelligent systems across the traditional embedded systems marketplace.

An Intelligent System centers on the integration of higher plane hardware and software technologies that allow for user reconfiguration, enable autonomous operation, access the internet, and extends the usage model of the system. For more details on the definition of our new category name see the definition section at the end of this report.

Not only are we seeing the volume of Intelligent Systems grow significantly, but the value of the data being captured by Intelligent Systems will grow even faster with each system connection. Intelligent Systems promise to enable new innovation; shift competition rapidly away from incumbents across the supply chain; and drive new value across a large fragmented Information, Communication, and Technology (ICT) industry.

Intelligent Systems will increase productivity and extend the life of systems because they are connected and each connection will drive more value as it allows companies and users to leverage, update through software, and enable new products and services within their marketplace. We can only imagine today how the data across all these Intelligent Systems will be used. What is apparent is that Intelligent Systems, in combination with cloud, location based services, and social networks, will be able to reach the last node or touch the consumer. Today, PCs and smartphones are what most companies consider intelligent, because they capture and process large amounts of data and we have become very familiar with the interfaces of each

platform. The transformation to Intelligent Systems will enable the extension of computing so that every system has the potential to capture data from other systems and the environment because each system will be connected and integrate sensors. This, in essence, is the opportunity that we attempt to capture in our report and we size and forecast across all the major markets that technology suppliers, service, and system companies are enabling with solutions that combine hardware and software to support consumer and enterprise service models.

For decades, the embedded systems market has been a very fragmented set of industries spanning Communications, Computing, Consumer, Energy, Healthcare/Medical, Industrial, and Transportation/Automotive systems Embedded systems accounted for almost 1.6 trillion dollars of value and 7.1 billion unit shipments in 2010. The overall industry is growing at a compound annual growth rate (CAGR) of 10% throughout our forecast period and should reach $2.6 trillion in revenues and nearly 11.6 billion units by 2015. This is not only growing at a faster pace than traditional IT spending, but also grows more than 1.5 times faster than the overall semiconductor industry.

Table 1 and Table 2 provide our overall revenue and unit forecast of the embedded and computing systems market segmented by major industry including capturing the value and volume of mobile phones, PCs, and servers. Traditionally, embedded systems have been specifically built systems that were not connected to a network and excluded mainstream, general computing products, such as mobile phones, PCs, and servers as part of our taxonomy. However, for this study, we have included these system categories to account for the fact that our new category of Intelligent Systems spans embedded and mainstream systems. Intelligent Systems shares several key features and attributes with traditional mainstream computing markets. Further, it is useful to compare and contrast the size and growth of mainstream versus embedded Intelligent Systems opportunities. Throughout the report IDC will highlight traditional embedded systems and intelligent systems in order to provide an overall view of the entire embedded system and semiconductor market opportunity.

Intelligent Systems

Intelligent Systems accounted for 19% of the overall unit volume of embedded systems in 2010. IDC forecasts that Intelligent Systems will account for more than one third of the volume of all embedded systems by 2015, but more impressive will capture more than 75% of the revenue opportunity. Just like smartphones, PCs, servers, automobiles, DTVs, STBs, and media tablets capture a higher level of value in today's ICT market; intelligent systems will have higher semiconductor content, be connected to a network and other systems, adopt new user interfaces including touch and other sensors, and support various OS ecosystems and service models. This higher level of intelligence will drive a large part of the revenue opportunity in the embedded systems market.

Figure 1 compares Intelligent Systems market opportunities in the embedded systems market versus mainstream computing segments for cellular phones, PCs, and Servers in terms of unit shipment growth for 2011-2012 time frame and five year CAGR of each segment, as well as each segment's share of 2011 unit shipments. Cellular phones are the fastest growing segment, both in systems and processors

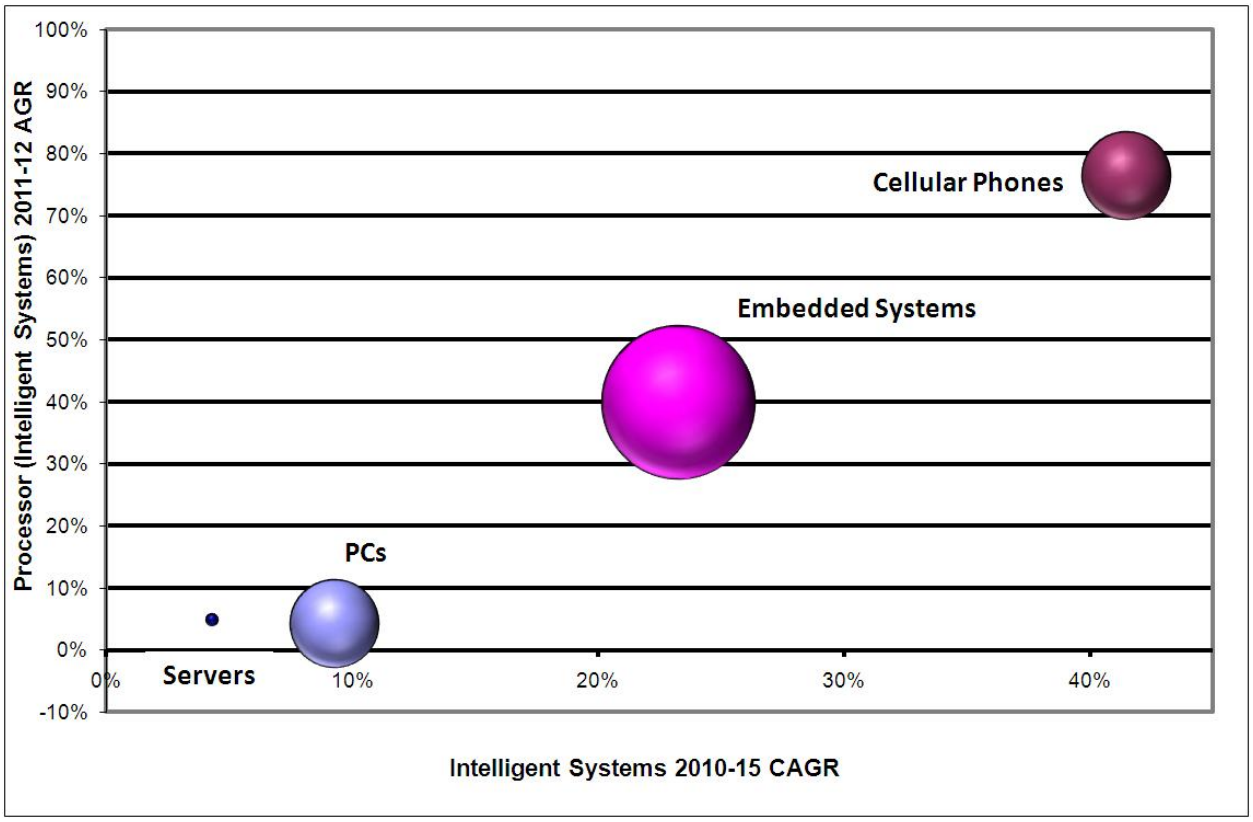
consumed, however traditional embedded markets generate 60% of all intelligent systems shipments. PCs, already intelligent systems under our definition, are growing more sedately compared to the other two major categories of Intelligent Systems.

Embedded Software, Tools, IP, and Platforms

Our forecast for this study of embedded systems does not include the value of commercial embedded system software, semiconductor merchant MPU IP, EDA tools, and development and reference platforms. We estimate that the size of these segments of the embedded system and semiconductor value chain is about $7.8 billion in 2010, and should grow at a compound annual growth rate of 7.6% over the next 5 years. By 2015, the overall value of these specific areas will reach $11.8 billion. Despite the healthy growth of this sector of the embedded systems area, IDC expects to see major shifts in the competitive landscape as past and upcoming acquisitions consolidate the vendors in the market. IDC expects that semiconductor, IP companies, and EDA vendors will continue scaling higher in the value chain by aggregating more system level IP, tools, and embedded software because the price of the chip is being defined primarily by the value of the software.

FIGURE 1

Worldwide Intelligent Systems Unit Shipments Comparison - Embedded Systems vs. Mainstream Systems 2011 Share and Growth



Notes:

Size of bubble equals 2011 share of system shipments. Growth of cell phone system shipments is driven by smartphones and multi core processor designs.

Source: IDC, 2011

TABLE 1

Worldwide Traditional Embedded Systems and Intelligent Systems Unit Shipments by Major Industry, 2010-2015 (Millions)

System Type	Industry	2010	2011	2012	2013	2014	2015	2010-2015 CAGR (%)
Traditional Embedded Systems	Communications	1,338	1,334	1,317	1,275	1,220	1,023	-5%
	Computing	2,625	3,029	3,295	3,625	3,951	4,124	9%
	Consumer	629	512	394	248	161	134	-27%
	Energy	0	0	1	1	1	2	43%
	Healthcare	2	2	3	3	3	3	2%
	Industrial	21	19	14	14	13	12	-10%
	Transportation	1,137	1,379	1,634	1,858	2,061	2,299	15%
Traditional Embedded Systems Total		5,754	6,276	6,659	7,023	7,410	7,597	6%
Intelligent Systems	Communications	425	630	845	1,056	1,267	1,603	30%
	Computing	444	476	530	586	654	718	10%
	Consumer	341	509	687	897	1,054	1,158	28%
	Energy	30	58	94	104	125	154	39%
	Healthcare	0	0	0	1	1	1	42%
	Industrial	48	57	70	81	92	101	16%
	Transportation	63	93	121	153	193	227	29%
Intelligent Systems Total		1,350	1,824	2,346	2,877	3,385	3,962	24%
Total Systems	Communications	1,763	1,964	2,162	2,332	2,487	2,626	8%
	Computing	3,069	3,505	3,825	4,211	4,605	4,842	10%
	Consumer	970	1,021	1,081	1,145	1,216	1,292	6%
	Energy	30	59	95	104	126	156	39%
	Healthcare	3	3	3	3	3	4	7%
	Industrial	69	76	84	95	104	113	10%
	Transportation	1,200	1,472	1,755	2,010	2,253	2,526	16%
Total Systems Total		7,104	8,099	9,005	9,900	10,795	11,559	10%

Notes:

An Intelligent System must include one or more programmable processing units integrated in a system-on-chip (SoC) or as standalone microprocessors, have internet connectivity, and support a high-level operating system (HLOS). A traditional embedded system lacks one or more of these requirements. See Definitions section for more detail.

Source: IDC, 2011

TABLE 2

Worldwide Traditional Embedded Systems and Intelligent Systems Revenues by Major Industry, 2010-2015 (US$M)

System Category	Industry	2010	2011	2012	2013	2014	2015	2010-2015 CAGR (%)
Traditional Embedded Systems	Communications	223,940	228,959	227,970	215,105	198,495	142,193	-9%
	Computing	81,779	86,446	90,801	95,813	99,600	103,433	5%
	Consumer	213,539	159,741	109,805	59,197	38,827	33,072	-31%
	Energy	22,766	26,425	27,812	38,777	48,556	61,007	22%
	Healthcare	54,206	55,904	59,052	62,176	62,912	57,838	1%
	Industrial	99,075	103,778	97,771	92,876	93,005	97,224	0%
	Transportation	44,750	52,031	59,690	65,868	73,346	83,452	13%
Traditional Embedded Systems Total		740,055	713,285	672,901	629,812	614,741	578,219	-5%
Intelligent Systems	Communications	213,120	295,302	379,398	458,372	546,473	671,551	26%
	Computing	385,826	396,460	417,525	445,217	474,493	503,830	5%
	Consumer	112,980	193,774	266,971	331,638	377,480	407,996	29%
	Energy	31,896	43,564	57,693	78,056	113,347	178,576	41%
	Healthcare	3,602	8,360	12,814	17,657	26,083	41,550	63%
	Industrial	76,192	98,825	112,452	137,040	159,325	177,420	18%
	Transportation	32,341	39,420	44,732	48,982	52,072	53,338	11%
Intelligent Systems Total		855,957	1,075,705	1,291,585	1,516,963	1,749,272	2,034,261	19%
Total Systems	Communications	437,061	524,261	607,368	673,477	744,968	813,745	13%
	Computing	467,606	482,906	508,326	541,031	574,093	607,263	5%
	Consumer	326,519	353,515	376,776	390,835	416,307	441,067	6%
	Energy	54,662	69,989	85,505	116,833	161,903	239,583	34%
	Healthcare	57,808	64,265	71,867	79,833	88,994	99,388	11%
	Industrial	175,267	202,604	210,223	229,916	252,330	274,644	9%
	Transportation	77,091	91,451	104,421	114,850	125,418	136,790	12%
Total Systems Total		1,596,013	1,788,990	1,964,487	2,146,775	2,364,013	2,612,480	10%

Notes:

An Intelligent System must include one or more programmable processing units integrated in a system-on-chip (SoC) or as standalone microprocessors, have internet connectivity, and support a high-level operating system (HLOS). A traditional embedded system lacks one or more of these requirements. See Definitions section for more detail.

Source: IDC, 2011

Embedded Semiconductor Suppliers and Architectures

The embedded semiconductor supplier landscape supports a diverse set of companies, architectures, and markets.

Even though there are suppliers that have large revenue pools coming from the traditional embedded market such as Renesas, Freescale, Infineon, Microchip Technologies, Texas Instruments, and others, there isn't a dominant supplier like there is today in mainstream categories such as PCs or mobile phones. The key reason for the balance among suppliers is because MCU and DSP companies differentiate with proprietary architectures and peripherals and support legacy developer investments in programming code. Also, success in embedded markets tends to require deeper knowledge of and relationships with specific value chains in the diverse range of end-use applications.

Traditionally, the microcontroller market has been driven primarily by 4- and 8-bit demand from white goods, consumer electronics, industrial, and automotive applications. Many of the market segments are deeply embedded with long product cycles on one spectrum, and short product life cycles and very low cost requirements on the other. The automotive market has become the largest driver of revenues for MCUs with more than one third of overall revenues coming from this market.

As we look forward, 32-bit MPUs will gradually displace MCUs. For example, even though the ARM architecture only accounts for a small part of the overall MCU market, MCU replacement is one of ARM's fastest growing licensing and volume shipment opportunities. Intelligent Systems will accelerate this migration as MCUs give way to 32-bit microprocessor architectures because there is more demand for 32-bit support, standard tools and peripherals, larger memory requirements, and scalable performance. Another threat to high-end MCUs are DSPs especially for low-power, battery-operated applications, since inherently DSPs can be tailored for lower power environments than MCUs for a given speed. Applications here include audio devices, biometric systems, and portable medical equipment. Coupled with WiFi, DSPs have a potential to be a low-cost participant in the embedded systems market.

Intel and ARM Ecosystem

ARM's concentration is not only in deeply embedded areas. The larger volume market still remains in cell phones, where ARM's architecture is dominant and accounts for 62% of all ARM-based shipments.

The growing support by Google's, Apple's, and Microsoft's operating systems has also helped propel the perception of ARM in mainstream computing markets where Intel has been the long standing market leader. Despite the recent attention that ARM has received, the battle between these two architectures is far from over. Both architectures face equal challenges. Designs are moving more toward heterogeneous system and silicon solutions placing more relevance on technologies and architectures beyond the core MPU. In addition, the customer base of both companies in core markets has fluctuated abruptly because of the influence of Apple

and Google in the market, and the lack of innovation from the rest of the OEMs. ARM's ecosystem also faces growing fragmentation from its largest partners who have diverging strategies and will force a reevaluation of this long standing and unique business model. Even though ARM has a large number of licensees, only 5 drive the majority of ARM's royalty and volumes. On the other hand, Intel has not executed in smartphones and tablets, and the markets are changing quickly without Intel's participation. Intel's manufacturing capability will only be fully leveraged with superior feature integration. The company is still working on putting all the pieces together to address these new opportunities.

These issues will extend into the embedded systems area for both architectures, but challenges can turn into opportunities with good execution, flexible business strategies, and good fortune.

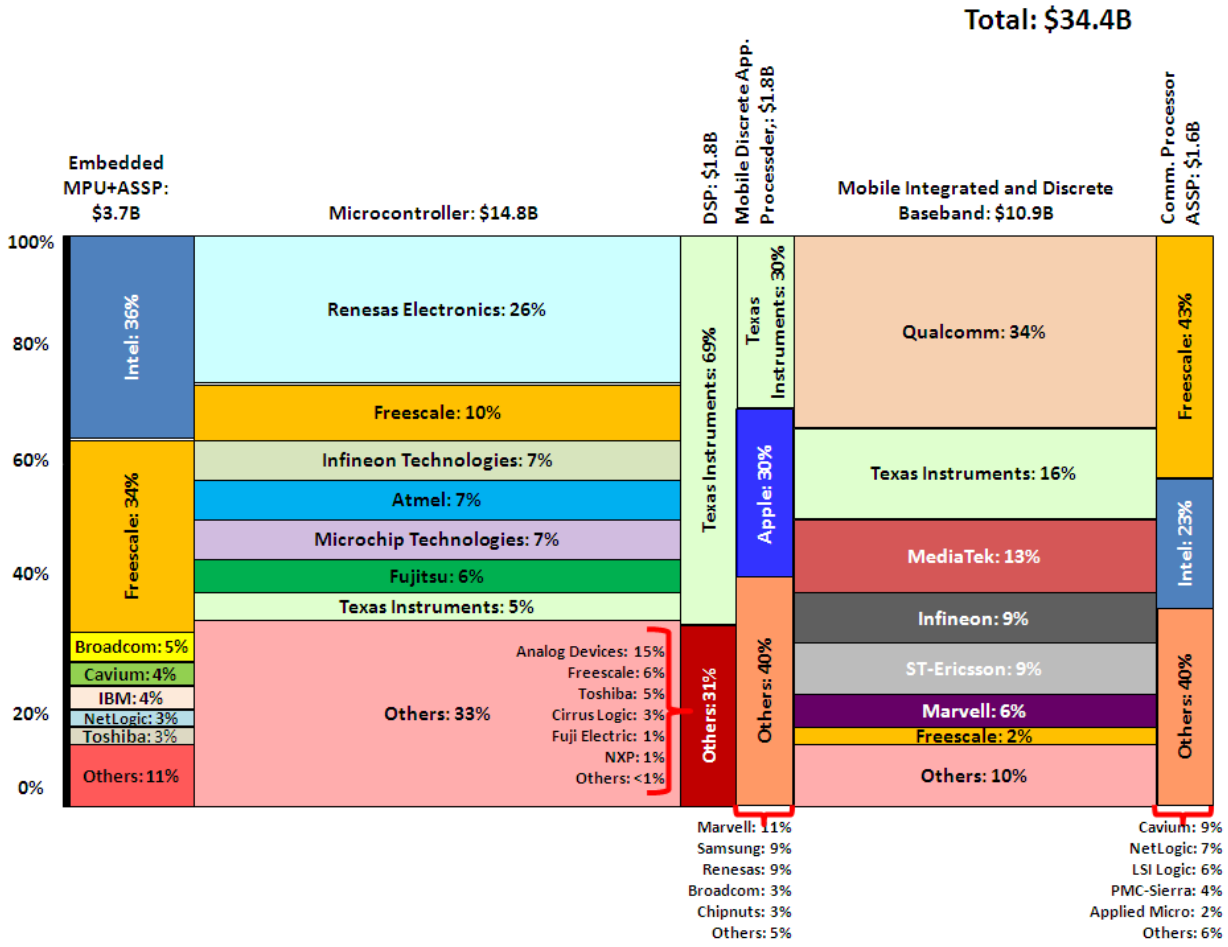
Embedded Semiconductor 2010 Market Size and Market Share: MCUs, MPUs, and SoCs

There are three primary semiconductor sectors that make up the overall size of the embedded semiconductor market. Today, the largest of the three areas is Microcontrollers which represented nearly $15 billion in revenues in 2010. Embedded MPU and SoCs, which are driven primarily by intelligent systems, accounted for $3.65 billion in 2010. DSP is the smallest product area of the three and rounded out the market with $1.8 billion in revenues in 2010. Figure 2 highlights the embedded and intelligent system semiconductor revenue market share for 2010.

As we look forward, how IDC recognizes and reports semiconductor revenues will change in order to include SoCs which are the largest portion of revenues in the era of Intelligent Systems. Figure 2 illustrates market share for some of the key SoC markets including Mobile Integrated and Discrete Baseband, Discrete Applications Processors, and Communications Processors.

FIGURE 2

Worldwide Embedded and Intelligent System Semiconductor Revenue Market Share (2010)



Notes:

Intel completed the acquisition of Infineon's wireless business unit in 2011. We did associate Infineon's 2010 market share in baseband to Intel's estimate.

Intel's communication processor estimate does not include chipset revenues.

Communications Processor ASSP market is a subset of Embedded MPU and ASSP.

Source: IDC, 2011

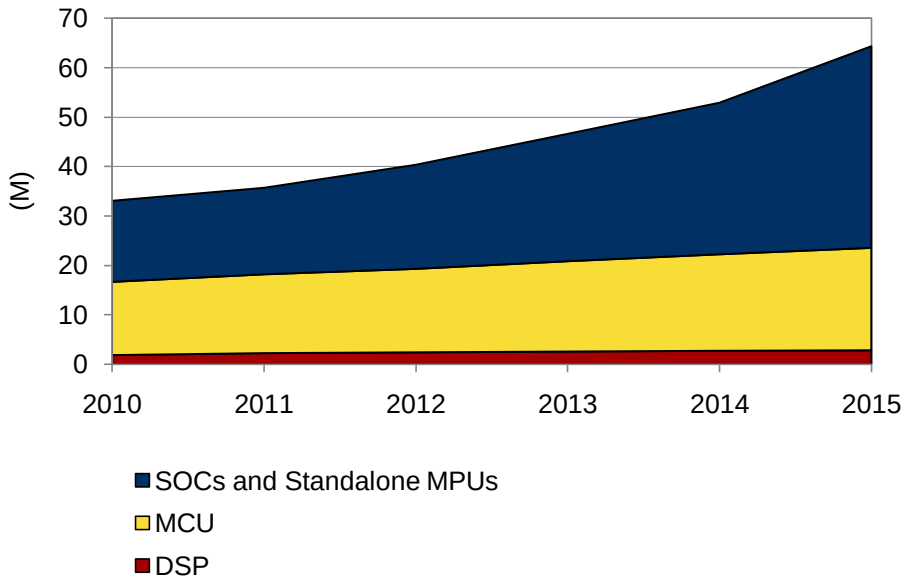
Embedded Systems Semiconductor Forecast

Semiconductor technology drives the expansion of the embedded systems market. Not only will we continue to see the adoption of Intelligent Systems grow dramatically, but the higher levels of semiconductor content will fuel a robust semiconductor market. Overall, revenues will grow from $33 billion in 2010 to $64.3 billion by 2015 growing at a CAGR of 20%. For an illustration of the forecast please see Figure 3.

FIGURE 3

Worldwide Embedded Semiconductor Forecast

CAGR 20%, SoCs and MPUs will account for almost two thirds of all revenues by 2015



Embedded systems semiconductor forecast does not include PCs and Cellular Phones.

Source: IDC, 2011

Era of Many Cores

Embedded microprocessor cores will continue to grow by billions of core shipments per year. PCs and smartphones already average more than two cores per system today, and even media tablets are quickly migrating to dual and quad core solutions leveraging the scalability of heterogeneous architectures. The direction of the market opportunity is very clear. By 2015, embedded systems will consume more than 14.4 billion microprocessor cores. Please see Table 3 and Table 4 which illustrate our unit forecast of processors and microprocessor cores by major industry and architecture over the next 5 years.

TABLE 3

Worldwide Total Systems Microprocessors Consumed and Microprocessor Cores Consumed by Major Industry, 2010-2015 (Millions)

Consumption Category	Industry	2010	2011	2012	2013	2014	2015	2010-2015 CAGR (%)
Microprocessors	Communications	2,244.68	2,745.31	3,178.68	3,522.45	3,764.35	3,962.94	12%
	Computing	1,164.38	1,333.02	1,535.31	1,715.45	1,905.48	2,080.26	12%
	Consumer	960.70	1,031.86	1,102.92	1,173.72	1,257.75	1,348.20	7%
	Energy	33.93	64.78	103.48	119.30	153.12	204.16	43%
	Healthcare	4.00	4.51	5.03	5.59	6.24	6.99	12%
	Industrial	71.41	81.30	92.51	106.75	120.63	134.82	14%
	Transportation	67.81	96.08	134.80	177.39	216.66	271.01	32%
Total		4,546.91	5,356.87	6,152.74	6,820.65	7,424.22	8,008.38	12%
Microprocessor Cores	Communications	4,220.97	5,247.65	5,769.50	6,738.15	7,428.79	8,287.18	14%
	Computing	1,623.04	1,917.62	2,253.32	2,651.32	3,055.18	3,521.48	17%
	Consumer	1,226.10	1,262.53	1,375.02	1,523.41	1,751.90	1,934.57	10%
	Energy	34.99	66.08	105.07	124.43	161.81	241.04	47%
	Healthcare	4.07	4.60	5.23	5.82	6.51	7.29	12%
	Industrial	71.41	82.68	94.65	111.81	132.26	150.02	16%
	Transportation	67.81	96.08	140.27	184.96	236.10	296.15	34%
Total Microprocessor Cores		7,248.38	8,677.25	9,743.07	11,339.89	12,772.55	14,437.73	15%

Notes:

Microprocessor cores are integrated in systems-on-chips (SoCs) or as standalone microprocessors.

Total Systems includes Traditional Embedded Systems and Intelligent Systems.

Source: IDC, 2011

TABLE 4

Worldwide Total Systems Microprocessor Cores Consumed by Architecture, 2010-2015 (Millions)

Microprocessor Cores	Architecture	2010	2011	2012	2013	2014	2015	2010-2015 CAGR (%)
	ARM	5,080.82	6,265.00	7,080.64	8,311.08	9,358.18	10,602.29	16%
	MIPS	512.12	563.93	655.99	736.12	830.34	908.25	12%
	Other	510.94	553.90	522.87	493.90	467.93	458.30	-2%
	Power Architecture	310.63	308.11	310.75	349.21	388.63	422.35	6%
	x86	833.87	986.31	1,172.82	1,449.59	1,727.46	2,046.54	20%
Total		7,248.38	8,677.25	9,743.07	11,339.89	12,772.55	14,437.73	15%

Notes:

Microprocessor cores are integrated in systems-on-chips (SoCs) or as standalone microprocessors.

Total Systems includes Traditional Embedded Systems and Intelligent Systems. ARM and MIPS based volumes do not include deeply embedded or MCU replacement markets.

Source: IDC, 2011

FUTURE OUTLOOK

Industry Impact

There are fundamental trends that continue to shape the landscape for embedded systems. As embedded system-on-chips and microprocessors scale with the next generation process nodes, improvements in performance, power, and integration combined with connectivity and robust operating systems will enable the industry to address the key market trends, including:

- Billions of internet users going online, using the Internet on mobile devices and Intelligent Systems to browse, social network, entertain, and conduct commerce. This means that computing, networking, and storage technologies must be able to scale.
- Emerging regions driving the next wave of volume growth
  - Most emerging markets are still just beginning to migrate to 3G and data. India, Brazil, Indonesia, and other emerging markets have tremendous growth ahead.
  - First Internet experience for the next billion users will not be primarily on a PC, this means that mobile apps will continue to explode.

- Multiple devices per person create more opportunity to deliver on the expectations that consumers demand which is to have the same rich experience on every device they own.

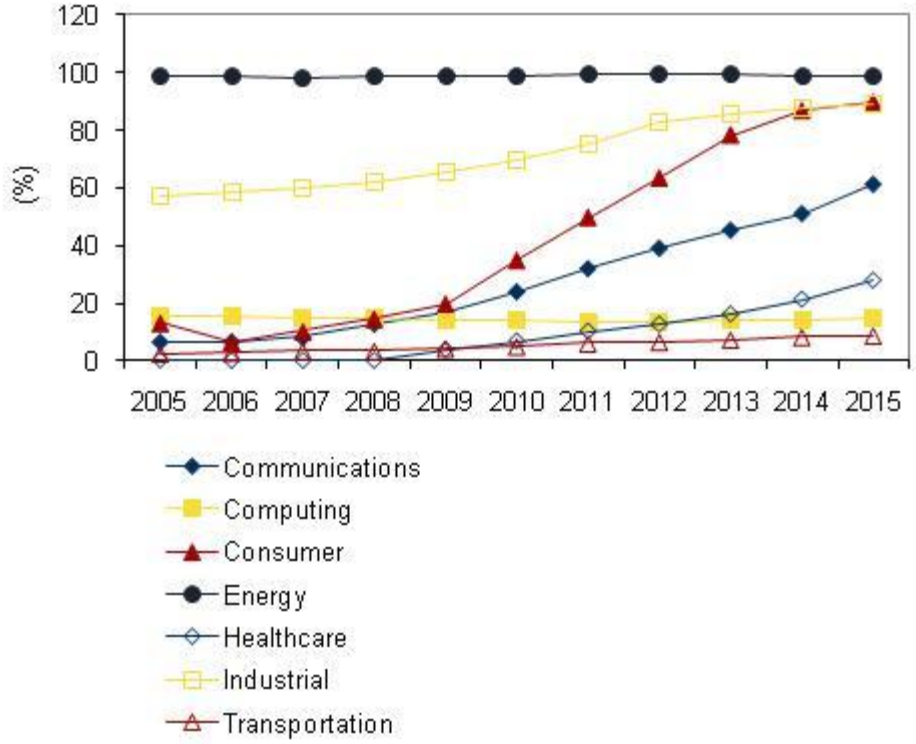
- Diversity of platforms, OS, and Apps will continue to expand for the next 3-5 years resulting in developers creating millions of apps that will extend beyond PCs and smartphones. Even though Android and Apple's IOS have captured a large part of today's volumes and mind share for mobile devices, there is plenty of opportunity for other alternative ecosystems and content players to materialize. Emerging markets share the same appetite for data, content, and services that advanced economies do, but are being underserved or are economically hindered. Service providers will also be more open to alternative ecosystems which will open a window of opportunity for Windows and a new consortium of companies supporting a unified ecosystem for Linux or HTML 5.

- Pervasive demand for data from consumers and enterprises will continue to exceed capacity of networks over our forecast period, so there is a large opportunity that emerges to build intelligent, efficient, and flexible networks. This will drive demand for heterogeneous solutions across the entire network.

Overall, these market trends point to more Intelligent Systems adopted throughout our forecast period. Please see Figure 4 for an illustration of the percent of Intelligent Systems by industry over the next five years. IDC forecasts that the volume for embedded systems will outpace any other mainstream system type, reaching 8.9 billion unit shipments by 2015. Figure 5 provides a volume comparison between embedded systems and other mainstream systems like PCs and cell phones.

FIGURE 4

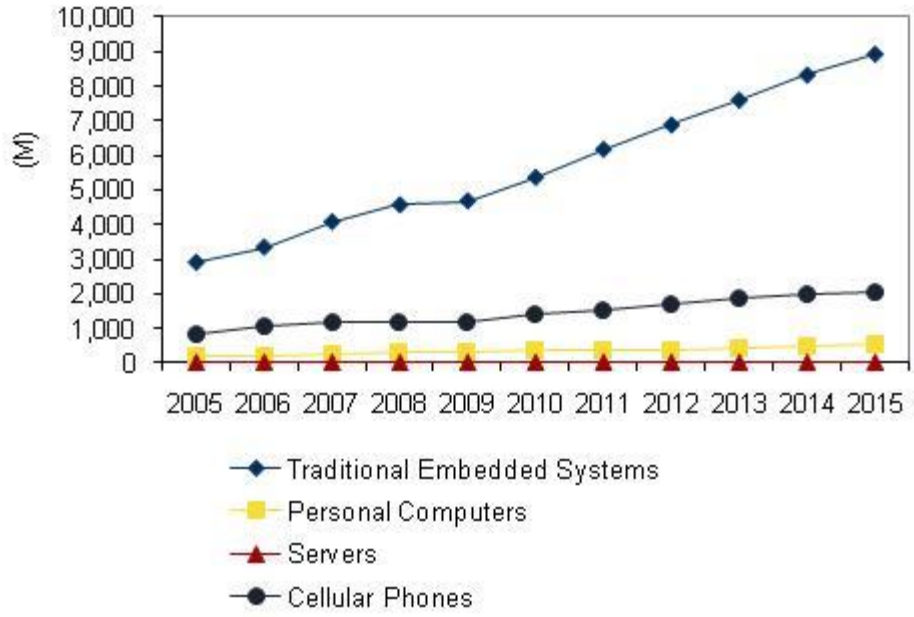
Worldwide - Intelligent Systems as Percentage of Total Systems in Each Major Industry (%)



Source: IDC, 2011

FIGURE 5

Worldwide Systems Unit Shipments - Traditional Embedded Systems vs. Mainstream Systems, 2005-2015 (Millions)

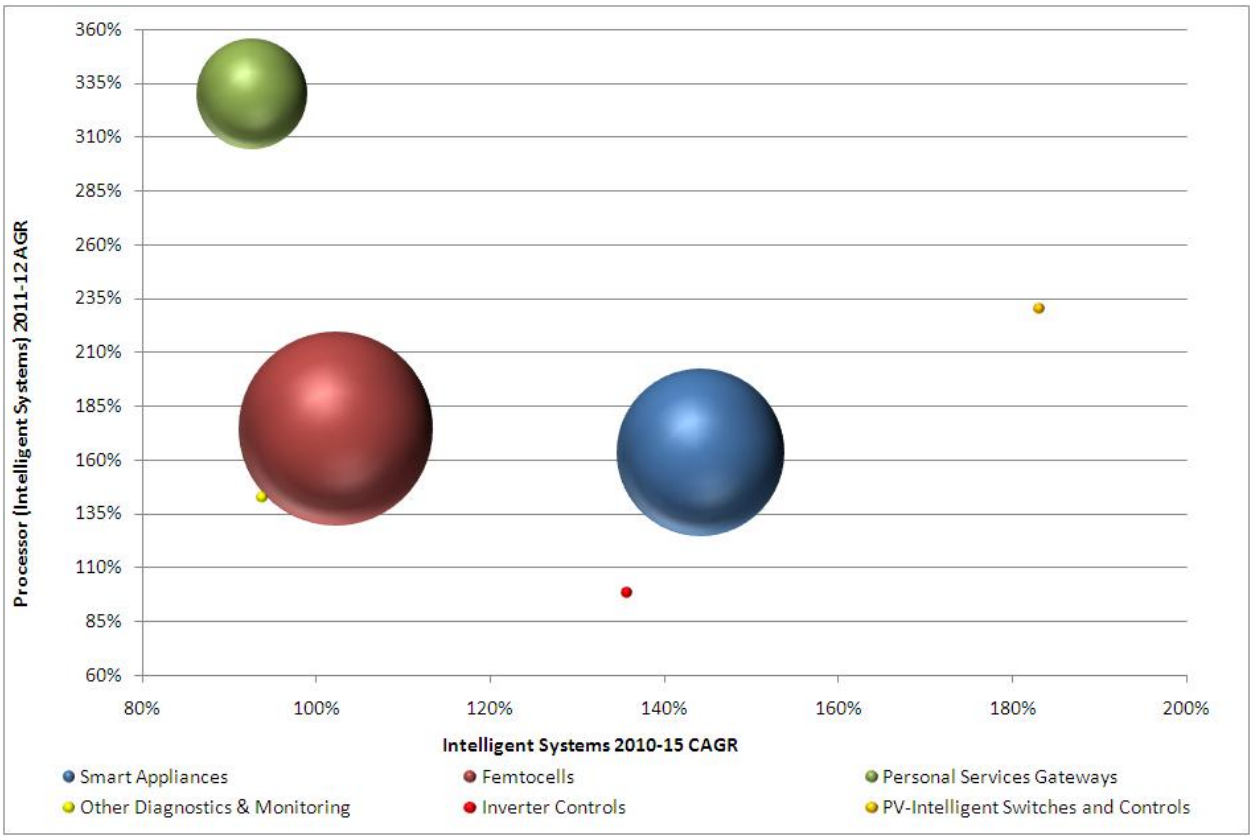


Source: IDC, 2011

Our embedded systems market model tracks over 168 different device categories that make up the opportunity for suppliers and vendors in the marketplace. Figure 6 highlights some of the fastest growing markets on a unit basis for Intelligent Systems.

FIGURE 6

Worldwide Intelligent Systems - Fastest Growing System Markets on a Unit Basis, 2011-2015



Notes:

Size of bubble equals 2011 share of system shipments

Does not include Personal Computers, Servers, and Cellular Phones

Source: IDC, 2011

ESSENTIAL GUIDANCE

The Intelligent System opportunity promises to be much larger. Beyond 2015, IDC predicts that Intelligent Systems' market momentum will accelerate as the ecosystem of hardware, software, and services vendors will bring more intelligence into systems through higher levels of performance and programmability, more forms of connectivity, increasing penetration of sensors, and a growing base of cloud based applications and data analytics that brings the "Internet of things" closer to reality.

LEARN MORE

Related Research

Please see the following documents for related research:

- *Worldwide Semiconductor 2011 Top 10 Predictions* (IDC #226843, February 2011)
- *A New Chapter for Freescale* (IDC #224589, September 2010)
- *Worldwide Communications Processor 2010 Vendor Shares* (IDC #228352, May 2011)
- *IDC Forecasts Worldwide Semiconductor Revenues to Reach $318 Billion in 2012 and Nearly $378 Billion in 2015* (IDC #prUS22948711, July 2011).
- *Worldwide Media Tablet and eReader Semiconductor 2011–2015 Forecast: The Explosion of an Opportunity* (IDC #227716, April 2011)
- *Worldwide Quarterly Electronics Manufacturing Services Vendor Shares, Version 1, 2011, Pivot Table: 1Q11* (IDC #230018, August 2011)
- *Worldwide IDC Electronics Manufacturing Services Market Forecast, 2010–2015* (IDC #226869, February 2011)

Definitions

This report focuses on a growing opportunity in the technology market that spans the mainstream systems and embedded systems computing markets. Embedded systems include traditional embedded systems and Intelligent Systems. Embedded systems are computer-based products with a limited range of functions and dedicated applications, as opposed to mainstream computing segments, such as personal computers, general servers, and mobile phones. Embedded systems range across Set-top Boxes, Digital TVs, routers, industrial automation equipment, automotive systems, and medical devices, to smart cards. In IDC's EMPU market model, IDC includes only microprocessor-based systems; it does not include deeply embedded MCUs and DSPs.

Intelligent Systems – Our definition of Intelligent Systems centers on the integration of higher plane hardware and software technologies that allow for user reconfiguration, enable autonomous operation, and extend the usage model of the system. Our classification takes into consideration the diversity of each system market, and adopts the relevant attributes that shape the way an application and end user reconfigures, recognizes, and interacts with the system or connection of systems. An Intelligent System must include:

- One or more programmable processing units, integrated in a system-on-chip (SoC) or as a standalone microprocessor. The integrated solution can either be a single or heterogeneous multi-core SoC that combines applications processors, graphic processors, media accelerators, and other processors and accelerators. The microprocessor core (cores) must support at least a 32-bit architecture and be capable of supporting a high level operating system (HLOS). Architectures that meet the requirements of our definition include: ARM, MIPS, Power Architecture, x86, SH, and other proprietary architectures. Intelligent systems do not require microcontrollers or digital signal processors to be considered in the category.

- Support of one or more operating systems, which can execute native or cloud based applications and they must be capable of internet browsing, and supports analytics collected by the system.

- Some of the key software and service attributes include wired or wireless connectivity to a network and other systems, security, manageability, identification, UI, and commerce and services enabled by cloud computing. Over time, our definition will continue to change in order to accommodate the emerging attributes and technologies, such as sensors, that will define the growth of the market.

Intelligent Systems can be either mainstream systems (personal computers, general servers, or cellular phones) or embedded systems.

Traditional Embedded Systems – Embedded systems includes systems with non-32 bit or above based architecture MPUs, but might not support an HLOS, or be connected.

Microprocessor (MPU) – A microprocessor is the central logic-processing semiconductor that enables intelligence in a system.

Application-Specific Integrated Circuit (ASIC) – An ASIC is a custom semiconductor device sold to a single OEM. Most, if not all, of the intellectual property comes from the OEM in this design. Varieties of custom ASICs include cell-based ASICs, gate array ASICs, new structured ASICs, and FPGAs.

Application-Specific Standard Product (ASSP) – An ASSP is an off-the-shelf semiconductor device sold to multiple OEMs. Most, if not all, of the intellectual property comes from the semiconductor supplier in this implementation.

Microcontroller (MCU) – This is a semiconductor device that provides processing support for applications such as servo and motor control. Major difference between MPUs and this device is that it has some form of ROM, EPROM, or EEPROM, which stores programmed customer supplied instructions. These instructions allow MCUs to carry-out control functions in various applications.

Digital Signal Processor (DSP) – A DSP is a specialized processor that performs mathematical operations to manipulate analog information that has been converted into a digital form e.g. in VoIP applications, DSPs are used to perform voice channel processing, echo cancellation, and compression/ decompression functions. DSPs

are primarily used in analog systems to process real time data. A-D and D-A converters needed to provide such functionality may sometimes be integrated on the DSP chip.

This report references data from IDC's EMPU Market Model that spans 168 system segments across 7 industries to size the embedded and semiconductor market opportunity. Please see Table 5 for a description of the model's segmentation.

TABLE 5

IDC Worldwide Embedded Market Model Device Segmentation

Industry	Device Category	Sub Device Category	Device
Transportation	Automotive	Automotive Control Devices	Automotive Control Devices
			ADAS
		Infotainment Devices	Communications
			Entertainment
	Transportation Telematics	Transportation Telematics	Commercial Telematics
			Passenger Telematics
Communications	Broadband Access	CPE	Business Gateways
			Cable CPE Modems
			DSL CPE Modems
			Residential Gateways (Wired)
			Personal Services Gateways
			Optical Networking Terminal (ONT)/Optical Network Unit (ONU)
		Infrastructure	DSLAM_MSAN_MTU_MDU
			Optical Line Terminal (OLT)
	Cellular Phones	Cellular Phones	SMART PHONES
			Cellular Phones (not including Smartphones)
	Cordless Telephony	DECT Phones	Cordless Telephony (DECT phones)
	Ethernet	Ethernet	Ethernet Switches - 10GbE Switches
			Ethernet Switches - GbE Switches
			Fast Ethernet Switches
	IMS	Infrastructure	IP Multimedia Subsystem Networking Equipment
	Network Security	Network Security	Firewall Appliance
			Unified Threat Management
			Intrusion Detection and Prevention
			Virtual Private Network Device
	Routers	Routers	Service Provider Core and Edge
			Enterprise/branch office high end
			Enterprise/branch office mid range
			Enterprise/branch office low end
			SOHO
	Telecom	Optical	SONET/SDH Add/drop Multiplexurs
			Multi-service Provisioning Platform
			Long Haul DWDM
			Metro DWDM
			Optical Cross-Connect
		Telecom	ATM-Multiservice Switch
	Video Conference	Video Conference	Video Conference

TABLE 5

IDC Worldwide Embedded Market Model Device Segmentation

Industry	Device Category	Sub Device Category	Device
	VoIP	Client Device	IP Media Phone
			VoIP Phones - Wireless Single Mode only
			Desktop IP phones
		Infrastructure	IP PBX
			Media Gateway-Softswitches
	Wireless	Wireless	Gateways - Wireless Access Points
			Fixed Wireless Access (Wi-Max)
			Cellular Infrastructure BSC-RNC
			Cellular Infrastructure BTS
			Femtocells
	Communications Other	Communications Other	Communications Other
Computing	Handheld Terminal	Handheld Terminal	PDA
	Printer	MFP	Enterprise MFP Color-B-W
			Workgroup MFP (Color & B/W)
			Production MFP
			Consumer MFP
		Other Printer	Production Printers
			Consumer Printer
		Print Only	Enterprise SFP (Color & B/W)
			Workgroup SFP (Color & B/W)
	Personal Computers	Desktop PC	Desktop PC
		Mobile PC	Mobile PC
		Tablet PC	Tablet PC - Convertible
			Tablet PC - Slate
	Projectors	Projectors	Projectors
			Projectors - Conference Room
	Servers	Servers	High-End Servers
			Midrange Servers
			Home NAS Server
			Volume Servers
		Telecom	Encoder-Transcoder
			Streaming-VoD servers
			High-End Servers (Telco)
			Midrange Servers (Telco)
			Volume Servers (Telco)
	Server & Storage Appliances	Server & Storage Appliances	Server Appliances
			Back-up and Archive Appliances
			SOHO Storage
	Storage Mechanisms	Storage Mechanisms	Hard Disk Drives
			Solid State Disk Drives
			Optical Disk Drives
			USB Drives
	Storage Systems	Storage Systems	Disk Storage Systems - External
			Tape Storage Automation Systems
			Optical Storage Systems
	Thin Clients	Thin Clients	Thin Clients - w/ local Browser

TABLE 5

IDC Worldwide Embedded Market Model Device Segmentation

Industry	Device Category	Sub Device Category	Device
			Thin Clients - w/o local Browser
	Flash Memory Cards	Flash Memory Cards	Flash Memory Cards
	Computing Other	Computing Other	Computing Other
Consumer	Digital Camera	Digital Camera	Digital Still Cameras
			Digital Video Camcorder
			IP camera
	Digital TV	Digital TV	LCD HD TV
			LCD SD TV
			Non-LCD DTV
	Digital Video Devices	Digital Video Devices	DVD player
			DVD recorder
			Blu-ray Player
	Gaming	Gaming	Gaming - Arcade Stations
			Gaming - Portable Consoles
			Gaming - Fixed Consoles
			Casino/Pachinko
	GPS	GPS	GPS Portable
	Mobile Internet Device	Mobile Internet Device	Media Tablet
			eReader
	Portable Media Devices	Portable Media Devices	Digital Audio Receivers
			Portable Media Players - HDD Based
			Portable Media Players - Flash Based
	Projector	Projector	Projectors - Home Use
	STB	STB	STB - Digital Cable
			Digital Media Adapters Servers
			STB - Digital Satellite
			STB - Free-to-Air
			Stand Alone DVR
			STB - IPTV
	Consumer Other	Consumer Other	Consumer Other
Industrial	Aerospace & Defense	Aerospace & Defense	Aerospace & Defense
	Kiosks	Kiosks	Digital Signage
			ATM
			Information
			Transaction
	POS	POS	PC Cash Register
			POS Transaction Terminal
			Handheld Systems - POS
	Video Surveillance	Video Surveillance	Video Servers
			Video Surveillance Storage
			Camera
			DVR
	Test & Measurement	Test & Measurement	Test & Measurement
			Remote Meters
	Industrial Automation	Industrial Automation	Single Board Computers
			Industrial Motor Drives

TABLE 5

IDC Worldwide Embedded Market Model Device Segmentation

Industry	Device Category	Sub Device Category	Device
			Robotics
			Semiconductor Manufacturing and Test Equipment
			Other Industrial Automation
			Human Machine Interface (HMI)
			Machine Vision
			Programmable Logic Controllers - Programmable Automation Controllers PLC - PAC)
			Distributed Controls
	Industrial PC	Handheld Terminal	Handheld Terminal - Commercial
		Industrial PC	Ruggedized/Industrial PC
	Other Industrial	Other Industrial	Other Industrial
Energy	Energy Consumption Point (Home/Bldg)	Smart Metering	Smart Meters-Electricity
			NAN Gateways & Data Concentrators
		Home/Bldg. Automation	HAN Gateways& Data Concentrators
			Smart Appliances
	PV	Inverters	Inverter Controls
		PV	Intelligent Switches and Controls
	Wind	Turbines	Turbine Control Systems
			Turbine Communication Systems
	Electricity T&D	Distribution Automation (Substation to Home)	Command and Controls
			Fault Detection and Isolation
	PHV/EV	PHV/EV Infrastructure	PHV/EV Charge Stations - Commercial
Healthcare	Medical Equipment	Pro_Active & Consumers	Pro_Active & Consumers
		Diagnostics & Monitoring	Bedside Terminals
			ECG/EKG
			Home Health Monitoring
			Other Diagnostics & Monitoring
			Patient Monitoring
		Imaging	CT
			Digital Pathology & Virtual Metrology
			Endoscopy
			ICE
			MRI
			Other_Imaging
			PACS
			Ultrasound
			X-Ray
		Therapeutics	Infusion Pumps
			Defibrillators
			Ventilators

Source: IDC, 2011

Methodology

IDC's research methodology for the embedded market encompasses qualitative and quantitative methods to study the market from the top-down and from the bottom-up perspective.

The top-down perspective emphasizes data gathering from major microprocessor IP companies, major MPU and SoC suppliers, and major embedded software vendors. IP vendors include ARM, MIPS, Imagination Technologies, and Tensilica. Embedded MPU and SoC suppliers include: Freescale, Intel, IBM, Applied Micro, Broadcom, Marvell, Renesas, TI, Qualcomm, Sigma Design, Sony, Core Logic, NXP, Toshiba, Fujitsu, Cavium Networks, Netlogic, Tilera, LSI, Samsung, Mediatek, MStar, Oracle, ST Microelectronics, Infineon, PMC-Sierra, and others. Embedded Software vendors include: Microsoft, Wind River, Greenhills, Montevista, QNX, Enea, and others.

The top-down research included surveys targeted towards gathering trends, insight on target markets, pricing, roadmaps, and actual shipments/ASPs/revenues. Key data included gathering data to determine the total number of volumes shipped in 2010. Interviews were conducted to build assumptions to support forecasts through 2015.

The bottom-up approach ties existing system forecasts to MPU usage ratios and penetration of architectures. Using device ASVs enable checks on MPU and SoC ASVs and overall BOM costs and spending on systems. Embedded MPU and SoC data was then further segmented by processor architecture – x86, Power Architecture, MIPS, ARM, SuperH, and Others; bus width - <32, 32, 64, >=128; and component type - Standalone processors, ASSPs (SoCs), ASICs (SoCs).

Embedded processor and systems data was then further analyzed to size the Intelligent Systems market and establish a single and multi-core shipment estimates through the forecast period.

Synopsis

This Industry Developments and Models study centers on identifying the transformation of the embedded systems industry, including providing context around the market's size and forecast, and indentifying key attributes that companies must address in order to capture the growth of the market.

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